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VIRGINIA POLYTECHNIC INST AND STATE UNIV BLACKSPURG
MULTICHARACTERISTIC QUALITY CONTROL.(U)

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FEB 82 D R JENSEN, P M GHARE, M R REYNOLDS

DAAG29-78-8-0172

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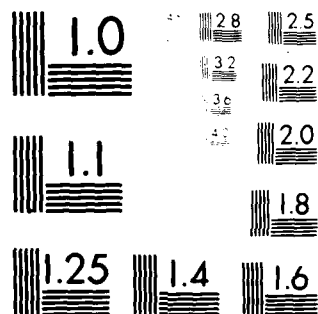
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MICROCOPY RESOLUTION TEST CHART
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Results are presented for research whose purpose was to develop quality control procedures for use when several quality characteristics are observed for each item. Special emphasis was to be given to developing diagnostic procedures for assigning causes when product quality is unacceptable.		

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FINAL REPORT

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6. AUTHORS OF REPORT: D.R. JENSEN and P.M. GHARE
7. PARTICIPATING SCIENTIFIC PERSONNEL

DEPARTMENT OF STATISTICS

DEPARTMENT OF INDUSTRIAL
ENGINEERING AND OPERATIONS RESEARCH

PRINCIPAL INVESTIGATORS

Dr. D.R. Jensen
Dr. M.R. Reynolds

Dr. P.M. Ghare

SUPPORTING PERSONNEL
AND DEGREES AWARDED

Mr. Y.V. Hui
(Ph.D. August 29, 1980.)

Mr. S.J. Sen
(Ph.D. unrelated to project.)

Mr. Mark O. Marcucci
(Ph.D. expected Summer 1982.)

Mr. J.A. Creiman
(M.S. expected Summer 1982.)

8. SUMMARY OF THE PRINCIPAL FINDINGS
(See attached pages.)
9. LIST OF PUBLICATIONS AND REPORTS
(See attached pages.)
10. LIST OF PAPERS PRESENTED AND WORKSHOPS ORGANIZED
(See attached pages.)
11. CONTINUING ACTIVITIES
(See attached pages.)



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8. SUMMARY OF THE PRINCIPAL FINDINGS

A. OBJECTIVES

The purpose was to develop quality control procedures for use when several quality characteristics are observed for each item. Special emphasis was to be given to developing diagnostic procedures for assigning causes when product quality is unacceptable.

B. THE PRINCIPAL RESULTS

These findings have appeared in published and unpublished reports, or in papers presented at professional meetings, or in materials presented to Workshops and Short Courses, or they are forthcoming in a Ph.D. Dissertation now in preparation.

1. Six different versions of Hotelling's T^2 charts were developed for use in monitoring process means in a variety of circumstances. Diagnostic procedures were devised for use with each type of T^2 chart.
2. Control charts for monitoring process dispersion parameters were developed, along with diagnostic procedures for use with these charts.
3. Control charts and diagnostics were developed for monitoring both variances in the bicharacteristic case.
4. Sequential acceptance procedures were developed for use when the failures follow a Weibull distribution.
5. Procedures were considered for monitoring the stationarity of models used in forecasting.
6. Disturbances in \bar{X} , R , and S^2 charts were studied owing to the use of estimates from a base period. Stochastic bounds were developed for distributions of run lengths associated with these charts.
7. Run lengths of the R , S^2 , and T^2 charts were studied when the monitored processes are nonstationary. Stochastic bounds for the actual run lengths were developed in terms of run-length distributions appropriate for stationary processes.
8. A basic probability inequality for the joint distribution of T^2 statistics was developed. This result has applications in assessing the performance of T^2 charts under nonstandard conditions.
9. Multivariate inequalities of Chebychev's type were developed. An application yields a universal distribution-free stochastic bound for the run lengths of S^2 charts for any underlying distribution having second moments.
10. The notion of an optimal control chart was developed in terms of properties of run lengths. The S^2 and T^2 charts were shown to be optimal among large classes of procedures in the sense that their run lengths are stochastically smallest when the respective processes are not in control.
11. A general model for monitoring a process was formulated using several levels of unacceptability having diagnostic value. Properties of the Markov process

governing the model were used to find means and variances of the number of interruptions and the numbers of adjustments of various types made to the process.

12. Charts were developed for monitoring the stationarity of the form of an input-output model for production, and for monitoring the residual variance of the process.

9. LIST OF PUBLICATIONS AND REPORTS

A. PAPERS PUBLISHED AND ACCEPTED

1. Jensen, D.R. (1980). "Bounds on the Joint Distribution of T_0^2 Statistics." *Ann. Inst. Statist. Math.* 32, 37-42.
2. Jensen, D.R. (1980). "Inequalities for Estimative and Predictive Probabilities." *Biometrical J.* 22, 739-743.
3. Ghare, P.M. (1981). "Sequential Tests under Weibull Distribution." *Proc. 1981 IEEE Symposium on Reliability and Maintainability*, pp.375-380.
4. Ghosh, B.K., Reynolds, M.R. and Hui, Y.V. (1981). "Shewhart \bar{X} -Charts with Estimated Process Variance." *Commun. Statist. -- Theor. Meth.* A10, 1797-1822.
5. Reynolds, M.R. and Ghosh, B.K. (1981). "Designing Control Charts for Means and Variances." *1981 ASQC Quality Congress Trans.*, pp.400-407.
6. Marcucci, M. and Jensen, D.R. (1981). "Nonstandard Distributions in Two-Stage Least Squares." *Proc. 1981 Business and Economic Statist. Sec., ASA*, pp.471-474.
7. Jensen, D.R. (1982). "Inequalities for Joint Distributions of Quadratic Forms." *SIAM J. Appl. Math.* 42 (To appear.)
8. Jensen, D.R. (1982). "An Optimal Property of S^2 Charts." *J. Statist. Comput. Simul.* 12 (To appear.)

B. DISSERTATION

Hui, Y.V. (1980). *Topics in Statistical Process Control*. Ph.D. Dissertation, Library, VPI&SU, Blacksburg, Virginia.

C. TECHNICAL REPORTS

Number	Authors, Title and Date
Q-1	Jensen, D.R. "Inequalities for Joint Distributions of Quadratic Forms." December 1979.
Q-2	Ghare, P.M., Hui, Y.V. and Jensen, D.R. "Multicharacteristic Quality Control: A Survey." March 1980.
Q-3	Jensen, D.R. and Hui, Y.V. "The Use of R and S^2 Charts under Nonstandard Conditions." March 1980.
Q-4	Ghosh, B.K., Reynolds, M.R. and Hui, Y.V. "Shewhart \bar{X} -Charts with Estimated Process Variance." March 1980.
Q-5	Hui, Y.V. and Jensen, D.R. "Markovian Time-Delay Sampling Policies." August 1980.
Q-6	Jensen, D.R., Hui, Y.V. and Ghare, P.M. "Monitoring an Input-Output Model for Production. I. The Control Charts." December 1980.
Q-7	Ghare, P.M. "Sequential Tests under Weibull Distribution." December 1980.
Q-8	Jensen, D.R. "Invariant Ordering and Order Preservation." May 1981.
Q-9	Marcucci, M. and Jensen, D.R. "Nonstandard Distributions in Two-Stage Least Squares." May 1981.
Q-10	Jensen, D.R. and Hui, Y.V. "Properties of T^2 Charts in Monitoring Process Means." June 1981.
Q-11	Jensen, D.R. "An Optimal Property of S^2 Charts." June 1981.
Q-12	Ghare, P.M. "Monitoring and Revalidation of Box-Jenkins Type Forecasting Models." March 1982.

D. PAPERS SUBMITTED FOR PUBLICATION

Hui, Y.V. and Jensen, D.R. "Markovian Time-Delay Sampling Policies", submitted to *Technometrics*.

Jensen, D.R., Hui, Y.V. and Ghare, P.M. "Monitoring an Input-Output Model for Production. I. The Control Charts." Submitted to *Management Science*.

Jensen, D.R. and Hui, Y.V. "The Use of R and S^2 Charts under Nonstandard Conditions."

10. LIST OF PAPERS PRESENTED AND WORKSHOPS ORGANIZED

A. PAPERS PRESENTED

"Shewhart \bar{X} -Charts with Estimated Process Variance," by B.K. Ghosh, M.R. Reynolds and Y.V. Hui, to the Annual Meeting of the American Statistical Association, Houston, August 1980.

"Sequential Tests under Weibull Distribution," by P.M. Ghare, to the *IEEE Reliability and Maintainability Symposium*, Philadelphia, January 1981.

"Monitoring and Revalidation of Box-Jenkins Type Forecasting Models," by P.M. Ghare, to the *International Symposium on Forecasting*, Quebec City, May 1981.

"The Comparison of Several Multinomial Distributions with a Standard," by M.O. Marcucci and D.R. Jensen to the *Virginia Academy of Science*, Norfolk, May 1981.

"Designing Control Charts for Means and Variances," by M.R. Reynolds and B.K. Ghosh, to the *Annual ASQC Quality Congress and Exposition*, San Francisco, May 1981.

"Nonstandard Distributions in Two-Stage Least Squares," by M.O. Marcucci and D.R. Jensen, to the *Business and Economic Section American Statistical Association*, Detroit, August 1981.

B. WORKSHOPS ORGANIZED

"Multicharacteristic Quality Control," by P.M. Ghare and D.R. Jensen, for research personnel at the Picatinny Arsenal, Dover, NJ, July 28-29, 1981.

"Statistical Procedures for Process Monitoring and Control," by P.M. Ghare and D.R. Jensen, the Annual Short Course preceding the Army Design Conference, Raleigh, NC, October 19-20, 1981.

11. CONTINUING ACTIVITIES

Work initiated under this project is continuing along several lines as follows.

Mr. Mark O. Marcucci is continuing work supported earlier toward a Ph.D. Dissertation in Statistics. The main focus of this work is process monitoring by attributes. He has developed generalized p-charts for the case of polychotomous responses. He is developing bivariate and multivariate versions of the p-charts and c-charts having diagnostic capabilities, using appropriate multidimensional distribution theory.

Mr. Ziv Barlach is undertaking studies toward a Ph.D. Dissertation in Industrial Engineering and Operations Research, in continuation of a project begun under ARO support. Specifically, his work centers on the problem of determining when an intervention has occurred in a time series, when using a forecasting model of Box-Jenkins type.